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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/544,390	04/06/2000	Todd M. Hess	E005640	7545

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EXAMINER	
THANGAVELU, KANDASAMY	
ART UNIT	**PAPER NUMBER**
2123	

DATE MAILED: 09/25/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	09/544,390	HESS ET AL.	
	Examiner	Art Unit	
	Kandasamy Thangavelu	2123	

CS

-- The MAILING DATE of this communication appears on the cover sheet with the c rrespondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on 06 April 2000 .

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 1-35 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☒ Claim(s) 19-23,33 and 34 is/are allowed.

6)☒ Claim(s) 1,4,9,14-18,24,29-32 and 35 is/are rejected.

7)☒ Claim(s) 2, 3, 5-8, 10-13 and 25-28 is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on 06 April 2000 is/are: a)☐ accepted or b)☒ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☒ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 2 .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

Introduction

1. Claims 1-35 of the application have been examined.

Information Disclosure Statement

2. Acknowledgment is made of the information disclosure statements filed on October 10, 2001 together with copies of the patents and papers. The patents and papers have been considered in reviewing the claims.

Drawings

3. The draft person has objected to the drawings; see a copy of Form PTO-948 for an explanation.

Claim Rejections - 35 USC § 102

4. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effect under this subsection of a national application published under section 122(b)

only if the international application designating the United States was published under Article 21(2)(a) of such treaty in the English language; or
(2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that a patent shall not be deemed filed in the United States for the purposes of this subsection based on the filing of an international application filed under the treaty defined in section 351(a).

5. Claims 31 and 32 are rejected under 35 U.S.C. 102(e) as being anticipated by **Berkowitz et al. (BE)** (U.S. Patent 5,488,561).

5.1 **BE** teaches Multivariable process control method and apparatus. Specifically, as per Claim 31, **BE** teaches an apparatus for controlling a process having process measurement variables associated therewith (Fig. 2 and Fig. 3); the apparatus comprising:

a digital processor (CL6, L21-24);

a model predictive controller having a model for the process therein (Fig. 2; CL4, L2-5); and

a simulation environment routine having a nonlinear model therein, the simulation environment routine executed by the digital processor (CL3, L53-56; CL7, L15-20; CL3, L3-7); for:

converting the linear model to the nonlinear model (CL3, L53-56); and

using the nonlinear model in a real time optimizer to compute targets for the model predictive controller (CL3, L3-7; CL 3, L15-20); and

passing the targets to the model predictive controller (CL6, L11-20).

Dependent claims

Per Claim 32: **BE** teaches the apparatus of Claim 31 further comprising a regulatory control system for controlling the process according to the targets passed to the model predictive controller (Fig. 2; CL6, L11-20).

Claim Rejections - 35 USC § 103

6. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains.

7. The factual inquiries set forth in *Graham* v. *John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.
2. Ascertaining the differences between the prior art and the claims at issue.
3. Resolving the level of ordinary skill in the pertinent art.
4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

8. Claims 1, 4, 9, 18 and 24 are rejected under 35 U.S.C. 103(a) as being unpatentable over **Shah et al. (SH)** (U.S. Patent 6,285,971) in view of **Berkowitz et al. (BE)** (U.S. Patent 5,488,561).

8.1 **SH** teaches method for real-time non-linear system state estimation and control. Specifically, as per Claim 1, **SH** teaches a method for controlling a process (Fig. 1; CL2, L54-62); comprising the steps of:

receiving plant measurement variables from a regulatory control system (Fig. 2; CL2, L54-62; CL3, L19-33);

applying the plant measurement variables to update one or more variables of a nonlinear model (Fig. 4; CL4, L56-62; CL6, L53 to CL7, L14; Figs. 7&8; CL13, L41-53); and

linearizing the updated nonlinear model (CL7, L15-29; CL13, L54-58).

SH teaches generating a MPC format model converted from the linearized model (Fig. 5; CL4, L63 to CL5, L10; CL6, L43-51; CL7, L15-29). **SH** does not expressly teach passing a MPC format model converted from the linearized model to a model predictive controller. **BE** teaches passing a MPC format model converted from the linearized model to a model predictive controller (CL1, L25-28; CL1, L38 to CL2, L5; CL3, L38-40; CL4, L2-5), as the model predictive controller allows introducing disturbances in the manipulated variables and calculating the response characteristics of the controlled variables; the calculated values of the controlled variables may be used to calculate the new set of moves for the manipulated variables; these moves when implemented have the effect of moving the controlled variables toward their optimum setpoints (CL1, L46-58). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **SH** with the method of **BE** that included passing a MPC format model converted from the linearized model to a model predictive controller, as the model predictive controller would allow introducing disturbances in the manipulated variables and calculating the response characteristics of the controlled variables; the

calculated values of the controlled variables could be used to calculate the new set of moves for the manipulated variables; these moves when implemented have the effect of moving the controlled variables toward their optimum setpoints.

Dependent claims

Per Claim 4: **SH** and **BE** teach the method of Claim 1. **SH** does not expressly teach applying the plant measurement variables to update the one or more variables of a nonlinear model includes the step of pretreating the plant measurement variables and using the pretreated plant measurement variables to update the nonlinear model variables. **BE** teaches applying the plant measurement variables to update the one or more variables of a nonlinear model includes the step of pretreating the plant measurement variables and using the pretreated plant measurement variables to update the nonlinear model variables (CL3, L26-32; CL3, L59-60), as single point variations can have a significant effect on the model output predictions (CL3, L61-65). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **SH** with the method of **BE** that included applying the plant measurement variables to update the one or more variables of a nonlinear model includes the step of pretreating the plant measurement variables and using the pretreated plant measurement variables to update the nonlinear model variables, as single point variations could have a significant effect on the model output predictions.

Per Claim 9: **SH** and **BE** teach the method of Claim 1. **SH** does not expressly teach applying the plant measurement variables to update variables of a nonlinear model further

includes the step of reconciling the pretreated plant measurement variables and using the reconciled and pretreated plant measurement variables to update the nonlinear model variables. **BE** teaches applying the plant measurement variables to update variables of a nonlinear model further includes the step of reconciling the pretreated plant measurement variables and using the reconciled and pretreated plant measurement variables to update the nonlinear model variables (CL3, L59-65), as single point variations can have a significant effect on the model output predictions (CL3, L61-65). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **SH** with the method of **BE** that included applying the plant measurement variables to update variables of a nonlinear model further includes the step of reconciling the pretreated plant measurement variables and using the reconciled and pretreated plant measurement variables to update the nonlinear model variables, as single point variations could have a significant effect on the model output predictions.

8.2 As per claim 18, **SH** teaches a method for controlling a process (Fig. 1; CL2, L54-62); comprising the steps of:

converting a nonlinear model to a linear model (CL7, L15-29; CL13, L54-58).

SH does not expressly teach converting a nonlinear model to a linear model for operation of a model predictive controller. **BE** teaches converting a nonlinear model to a linear model for operation of a model predictive controller (CL1, L25-28; CL1, L38 to CL2, L5; CL3, L38-40; CL4, L2-5), as the model predictive controller allows introducing disturbances in the manipulated variables and calculating the response characteristics of the controlled variables; the calculated values of the controlled variables may be used to calculate the new set of moves for

the manipulated variables; these moves when implemented have the effect of moving the controlled variables toward their optimum setpoints (CL1, L46-58). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **SH** with the method of **BE** that included converting a nonlinear model to a linear model for operation of a model predictive controller, as the model predictive controller would allow introducing disturbances in the manipulated variables and calculating the response characteristics of the controlled variables; the calculated values of the controlled variables could be used to calculate the new set of moves for the manipulated variables; these moves when implemented have the effect of moving the controlled variables toward their optimum setpoints.

SH does not expressly teach using the nonlinear model in a real time optimizer to compute targets for the model predictive controller and passing the targets to the controller. **BE** teaches using the nonlinear model in a real time optimizer to compute targets for the model predictive controller and passing the targets to the controller (CL3, L3-7; CL3, L15-20), as that provides a multivariable advanced control system for on-line optimal control of continuous processes (CL3, L3-5). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **SH** with the method of **BE** that included using the nonlinear model in a real time optimizer to compute targets for the model predictive controller and passing the targets to the controller, as that would provide a multivariable advanced control system for on-line optimal control of continuous processes.

8.3 As per Claim 24, **SH** teaches a method for controlling a process (Fig. 1; CL2, L54-62); comprising the steps of:

linearizing the updated nonlinear model (CL7, L15-29; CL13, L54-58); and

converting the linearized model to a MPC format model (Fig. 5; CL4, L63 to CL5, L10; CL6, L43-51; CL7, L15-29).

SH does not expressly teach passing the MPC format model to a model predictive controller. **BE** teaches passing the MPC format model to a model predictive controller (CL1, L25-28; CL1, L38 to CL2, L5; CL3, L38-40; CL4, L2-5), as the model predictive controller allows introducing disturbances in the manipulated variables and calculating the response characteristics of the controlled variables; the calculated values of the controlled variables may be used to calculate the new set of moves for the manipulated variables; these moves when implemented have the effect of moving the controlled variables toward their optimum setpoints (CL1, L46-58). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **SH** with the method of **BE** that included passing the MPC format model to a model predictive controller, as the model predictive controller would allow introducing disturbances in the manipulated variables and calculating the response characteristics of the controlled variables; the calculated values of the controlled variables could be used to calculate the new set of moves for the manipulated variables; these moves when implemented have the effect of moving the controlled variables toward their optimum setpoints.

SH does not expressly teach applying simulation stimuli to update one or more variables of a nonlinear model. **BE** teaches applying simulation stimuli to update one or more variables of a nonlinear model (CL1, L25-28; CL1, L38 to CL2, L5; CL3, L38-40; CL4, L2-5), as the simulations follow actual plant or process performance to permit prediction of the optimal set points of the manipulated variables (CL7, L18-20); and the approach permits efficient and

optimal control over the entire range of normal plant operation (CL3, L48-50). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **SH** with the method of **BE** that included applying simulation stimuli to update one or more variables of a nonlinear model, as the simulations would follow actual plant or process performance to permit prediction of the optimal set points of the manipulated variables and the approach would permit efficient and optimal control over the entire range of normal plant operation.

9. Claims 14-17 are rejected under 35 U.S.C. 103(a) as being unpatentable over **Shah et al. (SH)** (U.S. Patent 6,285,971) in view of **Berkowitz et al. (BE)** (U.S. Patent 5,488,561), and further in view of **Gouvea et al. (GO)** ("ROSSMPC: A new way of representing and analysing predictive controllers", Institution of Chemical Engineers, 1997).

9.1 As per Claim 14, **SH** and **BE** teach the method of Claim 1. **SH** teaches that the step of passing a MPC format model converted from the linearized model to a model predictive controller is replaced by the steps of converting the linearized model to a full order state space model (CL3, L19-45). **SH** teaches converting the fewer states state space model to a MPC format model (Fig. 5; CL4, L63 to CL5, L10; CL6, L43-51; CL7, L15-29).

SH and **BE** do not expressly teach creating from the full order state space model a state space model having fewer states then the full order state space model. **GO** teaches creating from the full order state space model a state space model having fewer states then the full order state space model (Pg 693, Abs, L7-13; Pg 695, CL2, Para 3 to Pg 696, CL1, Para 3; Pg 699, CL1,

Para 3), as the reduction in state space reduces the computational work involved in the closed loop analysis (Pg 693, Abs L 15-17); and the significant reduction in the number of states allows better knowledge of what is really happening in the closed loop system (Pg 699, CL1, Para 3). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **SH** and **BE** with the method of **GO** that included creating from the full order state space model a state space model having fewer states then the full order state space model, as the reduction in state space would reduce the computational work involved in the closed loop analysis and the significant reduction in the number of states would allow better knowledge of what is really happening in the closed loop system.

SH does not expressly teach passing the MPC format model to a model predictive controller. **BE** teaches passing the MPC format model to a model predictive controller (CL1, L25-28; CL1, L38 to CL2, L5; CL3, L38-40; CL4, L2-5), as the model predictive controller allows introducing disturbances in the manipulated variables and calculating the response characteristics of the controlled variables; the calculated values of the controlled variables may be used to calculate the new set of moves for the manipulated variables; these moves when implemented have the effect of moving the controlled variables toward their optimum setpoints (CL1, L46-58). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **SH** with the method of **BE** that included passing the MPC format model to a model predictive controller, as the model predictive controller would allow introducing disturbances in the manipulated variables and calculating the response characteristics of the controlled variables; the calculated values of the controlled variables could

be used to calculate the new set of moves for the manipulated variables; these moves when implemented have the effect of moving the controlled variables toward their optimum setpoints.

9.2 As per Claim 15, **SH** and **BE** teach the method of Claim 1. **SH** teaches that the step of passing a MPC format model converted from the linearized model to a model predictive controller is replaced by the steps of converting the linearized model to a MPC format model (Fig. 5; CL4, L63 to CL5, L10; CL6, L43-51; CL7, L15-29).

SH does not expressly teach converting the linearized model to a simplified model. **GO** teaches converting the linearized model to a simplified model (Pg 693, Abs, L7-13; Pg 695, CL2, Para 3 to Pg 696, CL1, Para 3; Pg 699, CL1, Para 3), as the reduction in state space reduces the computational work involved in the closed loop analysis (Pg 693, Abs L 15-17); and the significant reduction in the number of states allows better knowledge of what is really happening in the closed loop system (Pg 699, CL1, Para 3). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to combine the method of **SH** and **BE** with the method of **GO** that included converting the linearized model to a simplified model, as the reduction in state space would reduce the computational work involved in the closed loop analysis and the significant reduction in the number of states would allow better knowledge of what is really happening in the closed loop system.

SH and **GO** do not expressly teach passing the simplified MPC format model to a model predictive controller. **BE** teaches passing the simplified MPC format model to a model predictive controller (CL1, L25-28; CL1, L38 to CL2, L5; CL3, L38-40; CL4, L2-5), as the model predictive controller allows introducing disturbances in the manipulated variables and

calculating the response characteristics of the controlled variables; the calculated values of the controlled variables may be used to calculate the new set of moves for the manipulated variables; these moves when implemented have the effect of moving the controlled variables toward their optimum setpoints (CL1, L46-58). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **SH** and **GO** with the method of **BE** that included passing the simplified MPC format model to a model predictive controller, as the model predictive controller would allow introducing disturbances in the manipulated variables and calculating the response characteristics of the controlled variables; the calculated values of the controlled variables could be used to calculate the new set of moves for the manipulated variables; these moves when implemented have the effect of moving the controlled variables toward their optimum setpoints.

9.3 As per Claim 16, **SH, BE** and **GO** teach the method of Claim 14. **SH** does not expressly teach that the step of passing the MPC format model to a model predictive controller comprises the step of evaluating the performance of the MPC format model with the tuning for a presently existing model of the process in a model predictive controller versus the performance of the presently existing model with the tuning. **BE** teaches that the step of passing the MPC format model to a model predictive controller comprises the step of evaluating the performance of the MPC format model with the tuning for a presently existing model of the process in a model predictive controller versus the performance of the presently existing model with the tuning (CL7, L15-20; CL7, L56-60; Fig. 3; CL8, L6-10), as the appropriate tuning factors keep the magnitude of feedback corrections to a minimum (Cl7, L66 to CL8, L1); and the procedure

compensates for any systematic drift in performance of components (CL8, L10-12). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to combine the method of **SH** and **GO** with the method of **BE** that included the step of passing the MPC format model to a model predictive controller comprising the step of evaluating the performance of the MPC format model with the tuning for a presently existing model of the process in a model predictive controller versus the performance of the presently existing model with the tuning, as the appropriate tuning factors would keep the magnitude of feedback corrections to a minimum and the procedure would compensate for any systematic drift in performance of components.

SH and **GO** do not expressly teach passing the MPC format model with the presently existing model tuning to the model predictive controller when the performance evaluation of the MPC format model exceeds a first predetermined limit. **BE** teaches passing the MPC format model with the presently existing model tuning to the model predictive controller when the performance evaluation of the MPC format model exceeds a first predetermined limit (CL7, L15-20; CL7, L56-60; Fig. 3; CL8, L6-10), as the appropriate tuning factors keep the magnitude of feedback corrections to a minimum (Cl7, L66 to CL8, L1); and the procedure compensates for any systematic drift in performance of components (CL8, L10-12). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **SH** and **GO** with the method of **BE** that included passing the MPC format model with the presently existing model tuning to the model predictive controller when the performance evaluation of the MPC format model exceeds a first predetermined limit, as the appropriate

tuning factors would keep the magnitude of feedback corrections to a minimum and the procedure would compensate for any systematic drift in performance of components.

SH and **BE** do not expressly teach returning the MPC format model to the step of creating a MPC format model having fewer states than the full order state space model to change the number of states in the MPC format model when the performance evaluation for the MPC format model falls below the first predetermined limit. **GO** teaches returning the MPC format model to the step of creating a MPC format model having fewer states than the full order state space model to change the number of states in the MPC format model when the performance evaluation for the MPC format model falls below the first predetermined limit (Pg 693, Abs, L7-13; Pg 695, CL2, Para 3 to Pg 696, CL1, Para 3; Pg 699, CL1, Para 3), as the reduction in state space reduces the computational work involved in the closed loop analysis (Pg 693, Abs L 15-17); and the significant reduction in the number of states allows better knowledge of what is really happening in the closed loop system (Pg 699, CL1, Para 3). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **SH** and **BE** with the method of **GO** that included returning the MPC format model to the step of creating a MPC format model having fewer states than the full order state space model to change the number of states in the MPC format model when the performance evaluation for the MPC format model falls below the first predetermined limit, as the reduction in state space would reduce the computational work involved in the closed loop analysis and the significant reduction in the number of states would allow better knowledge of what is really happening in the closed loop system.

9.4 As per Claim 17, **SH, BE** and **GO** teach the method of Claim 14. **SH** does not expressly teach that the step of passing the MPC format model to a model predictive controller comprises the step of evaluating the performance of the MPC format model with the tuning for a presently existing model of the process in a model predictive controller versus the performance of the presently existing model with the tuning. **BE** teaches that the step of passing the MPC format model to a model predictive controller comprises the step of evaluating the performance of the MPC format model with the tuning for a presently existing model of the process in a model predictive controller versus the performance of the presently existing model with the tuning (CL7, L15-20; CL7, L56-60; Fig. 3; CL8, L6-10), as the appropriate tuning factors keep the magnitude of feedback corrections to a minimum (CL7, L66 to CL8, L1); and the procedure compensates for any systematic drift in performance of components (CL8, L10-12). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to combine the method of **SH** and **GO** with the method of **BE** that included the step of passing the MPC format model to a model predictive controller comprising the step of evaluating the performance of the MPC format model with the tuning for a presently existing model of the process in a model predictive controller versus the performance of the presently existing model with the tuning, as the appropriate tuning factors would keep the magnitude of feedback corrections to a minimum and the procedure would compensate for any systematic drift in performance of components.

SH and **GO** do not expressly teach passing the MPC format model with the presently existing model tuning to the model predictive controller when the performance evaluation exceeds a first predetermined limit. **BE** teaches passing the MPC format model with the

presently existing model tuning to the model predictive controller when the performance evaluation exceeds a first predetermined limit (CL7, L15-20; CL7, L56-60; Fig. 3; CL8, L6-10), as the appropriate tuning factors keep the magnitude of feedback corrections to a minimum (CL7, L66 to CL8, L1); and the procedure compensates for any systematic drift in performance of components (CL8, L10-12). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **SH** and **GO** with the method of **BE** that included passing the MPC format model with the presently existing model tuning to the model predictive controller when the performance evaluation exceeds a first predetermined limit, as the appropriate tuning factors would keep the magnitude of feedback corrections to a minimum and the procedure would compensate for any systematic drift in performance of components.

SH and **GO** do not expressly teach computing new tuning for the MPC format model when the performance evaluation falls below the first predetermined limit and repeating the evaluating step. **BE** teaches computing new tuning for the MPC format model when the performance evaluation falls below the first predetermined limit and repeating the evaluating step (CL7, L15-20; CL7, L56-60; Fig. 3; CL8, L6-10), as the appropriate tuning factors keep the magnitude of feedback corrections to a minimum (CL7, L66 to CL8, L1); and the procedure compensates for any systematic drift in performance of components (CL8, L10-12). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **SH** and **GO** with the method of **BE** that included computing new tuning for the MPC format model when the performance evaluation falls below the first predetermined limit and repeating the evaluating step, as the appropriate tuning factors would keep the

magnitude of feedback corrections to a minimum and the procedure would compensate for any systematic drift in performance of components.

SH and **BE** do not expressly teach returning the MPC format model to the step of creating a MPC format model having fewer states than the full order state space model to change the number of states in the MPC format model when the performance evaluation for the MPC format model falls below the first predetermined limit. **GO** teaches returning the MPC format model to the step of creating a MPC format model having fewer states than the full order state space model to change the number of states in the MPC format model when the performance evaluation for the MPC format model falls below the first predetermined limit (Pg 693, Abs, L7-13; Pg 695, CL2, Para 3 to Pg 696, CL1, Para 3; Pg 699, CL1, Para 3), as the reduction in state space reduces the computational work involved in the closed loop analysis (Pg 693, Abs L 15-17); and the significant reduction in the number of states allows better knowledge of what is really happening in the closed loop system (Pg 699, CL1, Para 3). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to modify the method of **SH** and **BE** with the method of **GO** that included returning the MPC format model to the step of creating a MPC format model having fewer states than the full order state space model to change the number of states in the MPC format model when the performance evaluation for the MPC format model falls below the first predetermined limit, as the reduction in state space would reduce the computational work involved in the closed loop analysis and the significant reduction in the number of states would allow better knowledge of what is really happening in the closed loop system.

10. Claims 29, 30 and 35 are rejected under 35 U.S.C. 103(a) as being unpatentable over **Berkowitz et al. (BE)** (U.S. Patent 5,488,561) in view of **Shah et al. (SH)** (U.S. Patent 6,285,971).

10.1 As per Claim 29, **BE** teaches an apparatus for controlling a process having process measurement variables associated therewith (Fig. 2; Fig. 3); the apparatus comprising:

a digital processor (CL6, L21-24);

a model predictive controller having a model for the process therein (Fig. 2; CL4, L2-5);

a simulation environment routine having a nonlinear model therein, the simulation environment routine executed by the digital processor (CL3, L53-56; CL7, L15-20; CL3, L3-7); for

applying process measurement variables to update one or more variables of the nonlinear model (CL3, L26-32; CL5, L17-21); and

linearizing the updated nonlinear model (Fig. 2; Fig 3, BLK 86: CL3, L37-39).

BE teaches passing a linearized nonlinear model to the model predictive controller (Fig. 2; CL1, L25-28; CL1, L38 to CL2, L5; CL3, L38-40; CL4, L2-5). **BE** does not expressly teach passing a MPC format model converted from the linearized nonlinear model. **SH** teaches passing a MPC format model converted from the linearized nonlinear model (Fig 5; CL4, L63 to CL5, L10; CL6, L43-51; CL7, L15-29), as the discrete model replaces the differential equations needed to describe the physical system by finite difference equations (CL6, L43-46). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to combine the apparatus of **BE** with the apparatus of **SH** that included passing a MPC format

model converted from the linearized nonlinear model to the model predictive controller, as the discrete model would replace the differential equations needed to describe the physical system by finite difference equations.

Per Claim 30: **BE** and **SH** teach the apparatus of Claim 29. **BE** teaches a regulatory control system for controlling the process (Fig. 2; Fig. 3); and

providing the process measurement variables to the simulation environment routine (CL3, L26-32; CL5, L17-21).

BE does not expressly teach a regulatory control system for controlling the process according to the MPC format model. **SH** teaches a regulatory control system for controlling the process according to the MPC format model (Fig 5; CL4, L63 to CL5, L10; CL6, L43-51; CL7, L15-29), as the discrete model replaces the differential equations needed to describe the physical system by finite difference equations (CL6, L43-46). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to combine the apparatus of **BE** with the apparatus of **SH** that included a regulatory control system for controlling the process according to the MPC format model, as the discrete model would replace the differential equations needed to describe the physical system by finite difference equations.

10.2 As per Claim 35, **BE** teaches an apparatus for controlling a process having process measurement variables associated therewith (Fig. 2; Fig. 3); the apparatus comprising:

a digital processor (CL6, L21-24);

a model predictive controller having a model for the process therein (Fig. 2; CL4, L2-5);

a simulation environment routine having a nonlinear model therein, the simulation environment routine executed by the digital processor (CL3, L53-56; CL7, L15-20; CL3, L3-7); for

applying simulation stimuli to update one or more variables of the nonlinear model (CL3, L53-56; CL7, L15-20; CL3, L3-7); and

linearizing the updated nonlinear model (Fig. 2; Fig 3, BLK 86: CL3, L37-39).

BE teaches passing a linearized nonlinear model to the model predictive controller (Fig. 2; CL1, L25-28; CL1, L38 to CL2, L5; CL3, L38-40; CL4, L2-5). **BE** does not expressly teach passing a MPC format model converted from the linearized nonlinear model. **SH** teaches passing a MPC format model converted from the linearized nonlinear model (Fig 5; CL4, L63 to CL5, L10; CL6, L43-51; CL7, L15-29), as the discrete model replaces the differential equations needed to describe the physical system by finite difference equations (CL6, L43-46). It would have been obvious to one of ordinary skill in the art at the time of Applicants' invention to combine the apparatus of **BE** with the apparatus of **SH** that included passing a MPC format model converted from the linearized nonlinear model to the model predictive controller, as the discrete model would replace the differential equations needed to describe the physical system by finite difference equations.

Allowable Subject Matter

11. Claims 2, 3, 5-8, 10-13 and 25-28 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

12. Claims 19-23, 33 and 34 are allowed.

Conclusion

13. The prior art made of record and not relied upon is considered pertinent to the Applicants' disclosure.

The following patents and papers are cited to further show the state of the art at the time of Applicants' invention with respect to model predictive controller development using simulation methodology for process control.

1. Kassmann et al., "Robust steady state target calculation for model predictive controller", U.S. Patent 6,381,505, April 2002.
2. Blevins et al., "Integrated advanced control blocks in process control systems", U.S. Patent 6,445,963, September 2002.
3. Shelley et al., "Structural control and monitoring using adaptive spatio-temporal filtering", U.S. Patent 6,549,858, April 2003.

4. Zhao et al., "Non-linear dynamic predictive device", U.S. Patent 6,453,308, September 2002.
5. Lu, "Systems for generating and using a lookup table with process facility control ...", U.S. Patent 6,542,782, April 2003.
6. Beller et al., "Method for modeling and control for delignification of pulping", U.S. Patent 5,060,132, October 1991.
7. Littman et al., "Decoupled feedforward-feedback control system", U.S. Patent 3,758,762, September 1973.
8. Zhao et al., "An identification approach to nonlinear state space model for industrial multivariable model predictive control", IEEE/AACC 1998.
9. Aoyama et al., "Implementation issues in quadratic model predictive control", IEEE/AACC 1997.

14. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Dr. Kandasamy Thangavelu whose telephone number is 703-305-0043. The examiner can normally be reached on Monday through Friday from 8:00 AM to 5:30 PM.

If attempts to reach examiner by telephone are unsuccessful, the examiner's supervisor, Kevin Teska, can be reached on (703) 305-9704. The fax phone number for the organization where this application or proceeding is assigned is 703-746-7329.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-305-9600.

K. Thangavelu
Art Unit 2123
September 11, 2003

ABroda

SAMUEL BRODA, ESQ.
PRIMARY EXAMINER